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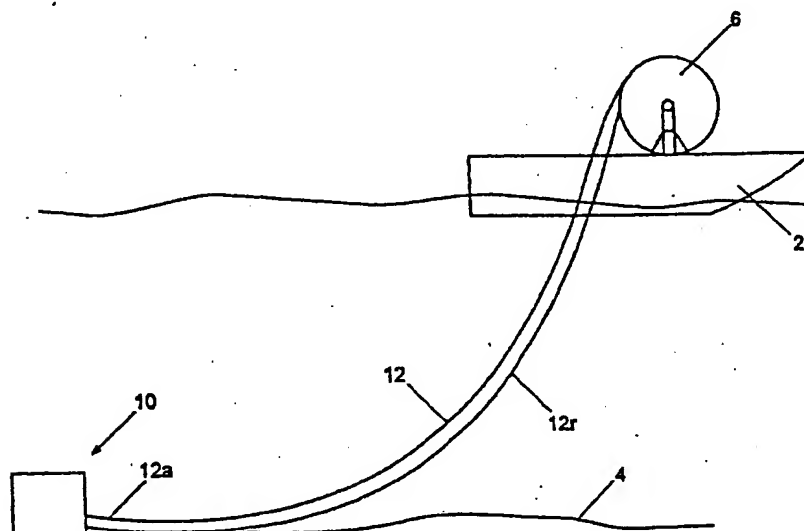
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ance Notes on Codes and Abbreviations" appearing at the begin-  
ning of each regular issue of the PCT Gazette.

(54) Title: METHOD OF FLOODING A PIPELINE



(57) Abstract: A method of flooding a pipeline (12) as it is being laid is disclosed. The method includes the use of an inlet to the pipeline that is attached to an end of the pipeline (12) either before the pipeline (12) enters the water or shortly thereafter. Water enters the pipeline (12) via the inlet as the pipeline (12) is laid, typically due to the hydrostatic head of water above the inlet, and the pipeline (12) is consequently flooded from one end (12a) as it is laid. Certain embodiments provide for chemicals to be added to the water as it floods the pipeline (12). Certain other embodiments also provide for filtering (14) of the water as it enters, and also there is the option for pressure testing the pipeline (12) once laid.

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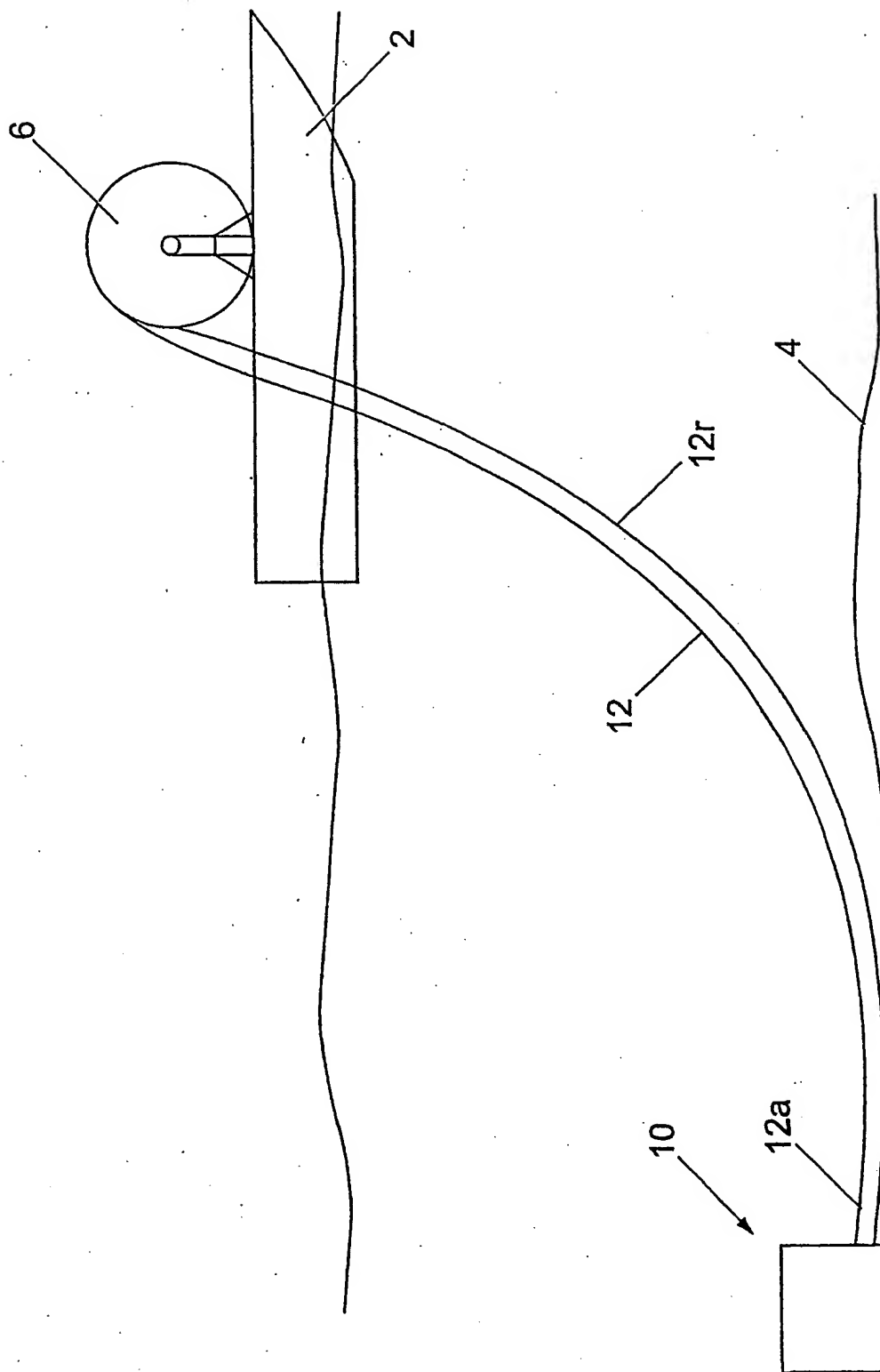
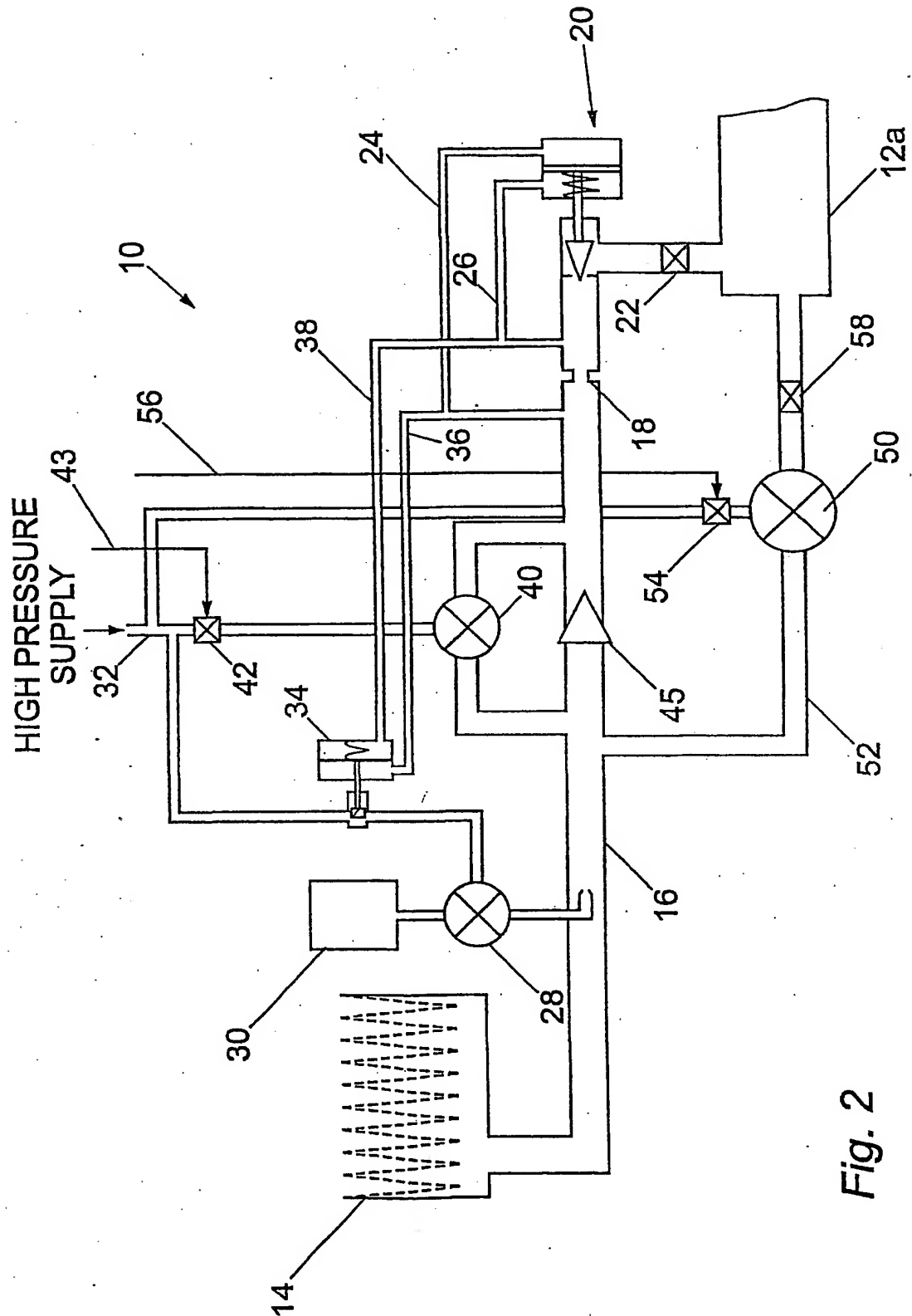


Fig. 1

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**Fig. 2**

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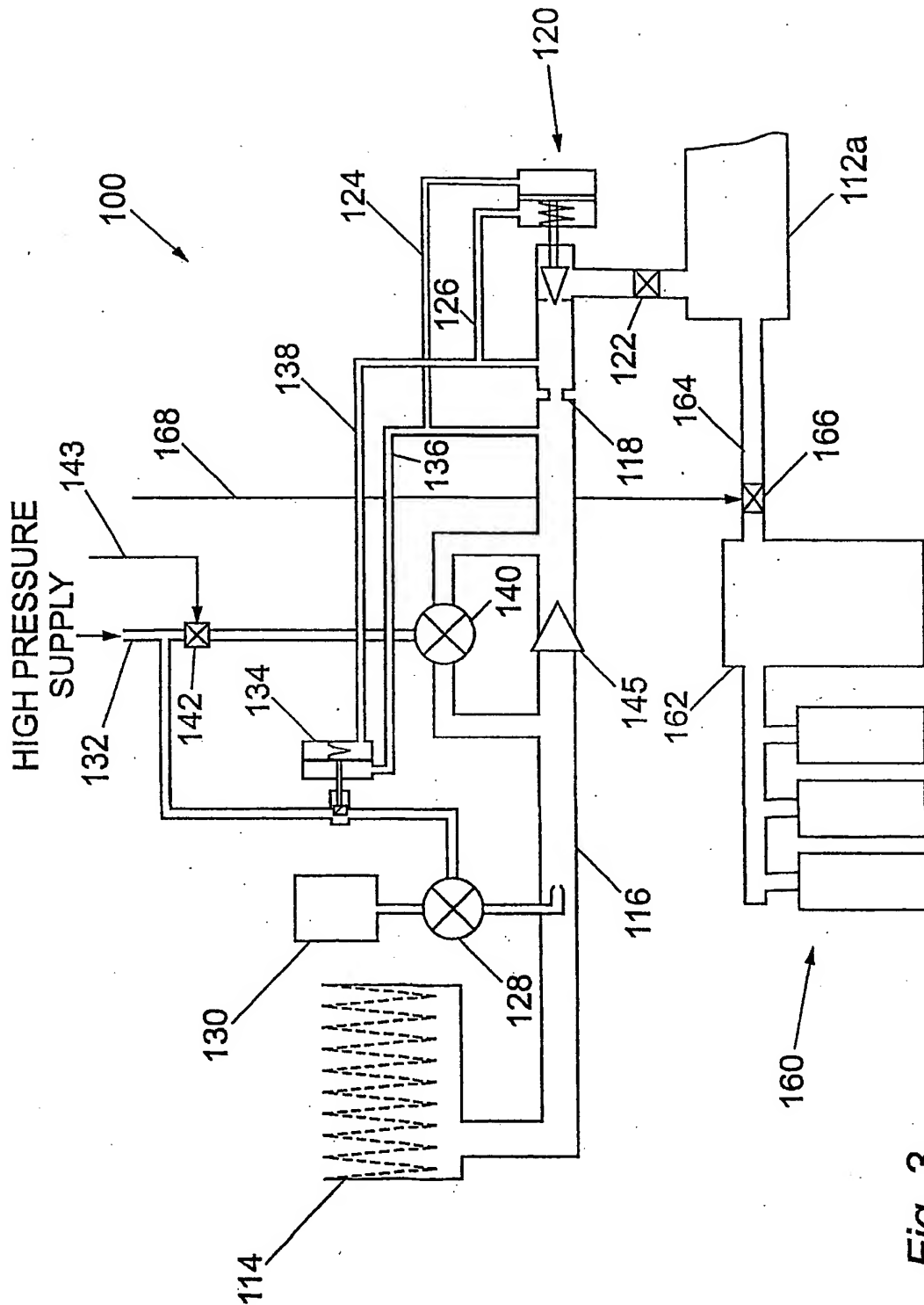


Fig. 3

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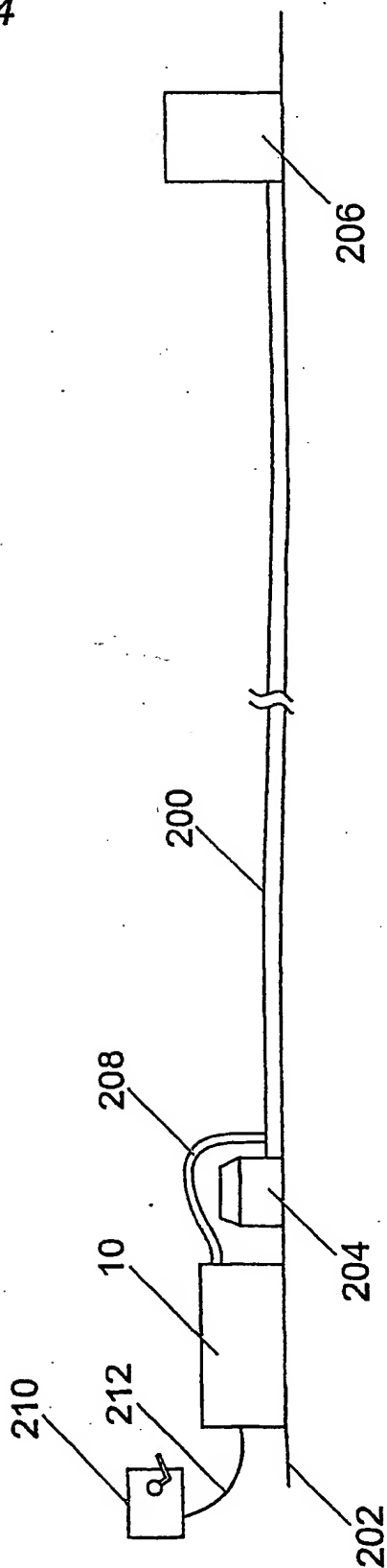


Fig. 4



1     "Method of Flooding a Pipeline"

2  
3     The present invention relates particularly, but not  
4     exclusively, to a method of flooding a subsea  
5     pipeline as it is being laid from a lay barge,  
6     vessel or the like.

7  
8     The laying of a subsea pipeline from a lay barge or  
9     vessel is well known in the art, and a number of  
10    different methods exist, such as J-lay, S-lay etc.  
11    Although the specific methods of laying the pipeline  
12    can vary, they all share a common problem in that  
13    the pipeline is generally relatively buoyant and can  
14    be affected by storms and tides that can move the  
15    pipeline.

16  
17    To deal with this long-recognised problem, it is  
18    conventional to increase the wall thickness of the  
19    pipeline to make it heavier and less prone to  
20    movement, and this increase can be around an eighth  
21    of an inch (approximately 3mm) or more. This has  
22    the advantage that the pipeline is made heavier and

1 thus less susceptible to movement by storms and  
2 tides.

3  
4 The movement of the pipeline by storms and tides can  
5 be reduced by laying the pipeline into a trench  
6 formed in the seabed.

7  
8 According to the present invention, there is  
9 provided a method of flooding a pipe as it is being  
10 laid in water, the method comprising the steps of  
11 providing an inlet to the pipe, the inlet having an  
12 opening to admit water, and allowing water to enter  
13 the pipe through the inlet as the pipe is being  
14 laid.

15  
16 The invention also provides a method of laying a  
17 pipeline in a body of water, the method comprising  
18 allowing the water to flood the pipe as it is being  
19 laid.

20  
21 The inlet is typically coupled to the pipe via a  
22 pipe inlet port, and thus the method typically  
23 includes the additional steps of coupling a pipe  
24 inlet port to the pipe, and coupling the inlet to  
25 the pipe inlet port.

26  
27 The method typically includes the additional step of  
28 coupling the inlet to the pipe before the pipe  
29 enters the water. Alternatively, the method  
30 typically includes the additional step of coupling  
31 the inlet to the pipe underwater. The coupling of  
32 the inlet to the pipe underwater may be achieved by

1 use of a diver, remotely operated vehicle (ROV) or  
2 an autonomous vehicle (AUV).

3  
4 The method typically includes the additional step of  
5 actuating flooding of the pipe. The step of  
6 actuating flooding of the pipe typically involves  
7 opening an isolating valve located in the inlet (or  
8 at another suitable location). The isolating valve  
9 can be opened at the surface, or underwater by a  
10 diver, ROV or AUV. Alternatively, the isolating  
11 valve may be opened remotely (e.g. using a control  
12 line from the surface).

13  
14 The method preferably includes the additional step  
15 of filtering the water that enters the pipe. Thus,  
16 the method typically includes providing an intake  
17 filter at the inlet.

18  
19 The pipe is typically flooded from the end that is  
20 in the water, rather than from the end of the pipe  
21 that remains on the lay barge. Embodiments of the  
22 present invention provide significant advantages in  
23 that the hydrostatic head of water above the pipe  
24 (i.e. the pressure difference between the air- or  
25 gas-filled interior of the pipe and the surrounding  
26 water) can be used to flood the pipe. Thus, a pump  
27 may not be required.

28  
29 Flooding the pipe from the end that is underwater  
30 means that the end of the pipe that is on the barge  
31 (that is the remainder of the pipe that has not been



1     laid) can provide a vent to the atmosphere for the  
2     air or gas in the pipe during flooding.

3  
4     Embodiments of the present invention also provide  
5     the advantage that the flow of water into the  
6     pipeline can be controlled, and thus the pipe is  
7     less likely to be moved during flooding.

8  
9     Furthermore, flooding of the pipe whilst it is being  
10    laid has the advantage that the pipe is made,  
11    relatively heavy shortly after it enters the water,  
12    yet it is not excessively weighted before then.  
13    Thus, it is less susceptible to storms, tides and  
14    other adverse weather and sea conditions, whilst  
15    being easy to handle.

16  
17    The method optionally includes the additional step  
18    of adding chemicals to the water that enters the  
19    pipe.

20  
21    The method typically includes the additional step of  
22    pumping fluid into the pipe to complete flooding of  
23    the pipe. This can be done by a boost pump where  
24    the pressure difference between the interior of the  
25    pipe and the surrounding seawater diminishes, and  
26    flooding of the pipe ceases. The boost pump can be  
27    actuated using a remotely operated valve and a  
28    control line, or can be actuated by a diver, ROV or  
29    AUV. Alternatively, the boost pump may be actuated  
30    automatically in response to a drop in the flow rate  
31    of water into the pipe. Thus, the method typically  
32    includes the additional step of actuating a pump,

1 typically a boost pump, to complete flooding of the  
2 pipe.

3  
4 The method optionally includes the additional step  
5 of pressure testing the pipe after it has been  
6 flooded. The step of pressure testing the pipe  
7 typically involves the actuation of a subsea pump,  
8 although other methods of pressure testing may be  
9 used.

10  
11 The pipe typically comprises a pipeline, and  
12 preferably a subsea pipeline.

13  
14 GB2303895B, the entire disclosure of which is  
15 incorporated herein by reference, describes a  
16 suitable underwater pipeline apparatus for admitting  
17 water into the pipeline in a controlled manner,  
18 typically through a flow regulator and a filtration  
19 system.

20  
21 Embodiments of the present invention shall now be  
22 described, by way of example only, with reference to  
23 the accompanying drawings, in which:-

24 Fig. 1 is a schematic representation of a  
25 subsea pipeline being laid from a lay barge;  
26 Fig. 2 is a schematic representation of  
27 apparatus for flooding a pipeline;  
28 Fig. 3 is a schematic representation of  
29 alternative apparatus for flooding a pipeline;  
30 and

1        Fig. 4 is a schematic representation of a  
2        pipeline laid on the seabed between two subsea  
3        installations.

4  
5        Referring to the drawings, Fig. 1 shows a schematic  
6        representation of a subsea pipeline 12 being laid  
7        from a lay barge 2. The lay barge 2 can be of any  
8        conventional type and can use any one of a variety  
9        of different pipeline laying methods, such as J-lay,  
10       S-lay etc. The pipeline 12 is laid directly onto  
11       the seabed 4, and in this particular example, the  
12       pipeline 12 is not laid into a trench or the like,  
13       although this may be an option. The stability of  
14       pipeline 12 in rough weather or sea conditions will  
15       be increased where it is laid into a pre-defined  
16       trench.

17  
18       The pipeline 12 may be of any conventional size and  
19       type, and is generally initially air- or gas-filled  
20       as it is paid out from a reel or drum 6, or coupled  
21       together in successive lengths on the lay barge 2.  
22       Thus, the pipeline 12 is relatively light and can be  
23       affected by storms and tides when it is being laid,  
24       and after it has been laid.

25  
26       Apparatus 10 (best shown in Fig. 2) for flooding the  
27       pipeline 12 is attached to an end 12a of the  
28       pipeline 12 and is used to flood the pipeline 12  
29       typically with seawater, as the pipeline 12 is laid  
30       onto the seabed 4. The end 12a is typically the end  
31       of the pipeline 12 that enters the water first.  
32       This may be at the beginning of the laying process

1 or can be at any intermediate point should the  
2 process be stopped and re-started, for example due  
3 to adverse weather conditions. Fig. 1 shows the  
4 apparatus 10 already located on the seabed 4, but it  
5 is preferably attached to end 12a of the pipeline 12  
6 on the lay barge 2 and can then be lowered to the  
7 seabed 4 with the end 12a of the pipeline 12 as it  
8 is laid.

9  
10 Apparatus 10 can be lowered to the seabed 4 using  
11 any conventional method or apparatus, such as a  
12 crane. It will be appreciated that apparatus 10 can  
13 be coupled to end 12a at any convenient time, and it  
14 is typically coupled before the end 12a of the  
15 pipeline 12 enters the water, although this is not  
16 essential. For example, a diver or ROV could be  
17 used to couple apparatus 10 to end 12a just after  
18 the end 12a has entered the water.

19  
20 The pipeline 12 is thus flooded from the end 12a  
21 that is in the water. Flooding the pipeline 12 from  
22 the end 12a that is underwater allows the  
23 hydrostatic pressure difference between the interior  
24 of the pipeline 12 that is typically initially air-  
25 or gas-filled and the surrounding water to be used  
26 to flood the pipeline 12. Thus, there is generally  
27 no requirement for a pump with a large capacity. A  
28 pump of lesser capacity may be required to flood the  
29 pipeline 12 if the hydrostatic pressure equalises.

30  
31 As the water enters the pipeline 12 from the end 12a  
32 that is underwater, the pipeline 12 can be vented to

1 atmosphere through the distal end on the barge 2.  
2 This can provide advantages in that it may not be  
3 necessary to vent the pipeline 12 underwater.

4  
5 Flooding the pipeline 12 from the end 12a that is in  
6 the water provides the advantage that the pipeline  
7 12 can be flooded with relatively little movement of  
8 it. This is because the pipeline 12 is  
9 progressively flooded from the end 12a as it is  
10 being laid, and the flow of water into it can be  
11 controlled. The control over the flow rate provides  
12 the advantage that the water does not cascade into  
13 the pipeline 12 in an uncontrolled manner where  
14 excessive flow rates may cause movement of the  
15 pipeline 12. Furthermore, the water that is used to  
16 flood pipeline 12 flows progressively along it as it  
17 is being laid. The pipeline 12 will therefore flood  
18 gradually from end 12a as it is paid out from the  
19 lay barge 2.

20  
21 Apparatus 10 and the use thereof to flood pipelines  
22 has been described herein with reference to the  
23 laying of pipelines in the sea and the flooding  
24 thereof using seawater, but it will be noted that  
25 the pipeline 12 may be laid in a lake or the like  
26 and flooded with fresh water, rather than seawater.

27  
28 Referring now to Fig. 2, an exemplary embodiment of  
29 apparatus 10 for flooding of the pipeline 12 as it  
30 is being laid shall now be described. Apparatus 10  
31 is similar to that described in GB2303895B, the

1 entire disclosure of which is incorporated herein by  
2 reference.

3  
4 Apparatus 10 preferably includes an intake filter 14  
5 that is capable of straining the surrounding  
6 seawater to remove substantially all of the  
7 contaminants before it is allowed to enter the  
8 pipeline 12. However, it is sufficient for the  
9 intake filter 14 to strain the seawater to the  
10 required standard only, and need not necessarily  
11 remove all contaminants. The intake filter 14 is  
12 also preferably capable of providing water at a flow  
13 rate necessary to flood the pipeline 12.

14  
15 The intake filter 14 is coupled to the end 12a of  
16 the pipeline 12 via a conduit 16 that includes an  
17 orifice plate 18, a variable choke, generally  
18 designated 20, and an isolating valve 22. The  
19 variable choke 20 can be used to adjust the flow of  
20 water into the pipeline 12 to compensate for the  
21 varying hydrostatic head, and is automatically  
22 controlled in response to the existing rate of flow  
23 by use of differential pressure lines 24, 26. One  
24 pressure line 24, 26 is coupled to a first side of  
25 the orifice plate 18, and the other line 24, 26 is  
26 coupled to the other side of the plate 18.

27  
28 Alternatively, the variable choke 20 can be  
29 automatically controlled using a pressure-operated  
30 device such as a diaphragm that is coupled to each  
31 side of the orifice plate 18.

32

1 As the pipeline 12 is laid from the lay barge 2, the  
2 pipeline 12 can be provided from the reel or drum 6  
3 (as shown schematically in Fig. 1) or can comprise a  
4 number of lengths of pipe that are welded together  
5 on the lay barge 2 and then lowered into the sea.  
6 The latter method is generally used where the pipe  
7 is of a large diameter and cannot be wound onto a  
8 reel or drum. The laying operation can often be  
9 stopped and started, particularly in the latter  
10 method, and this can cause problems where chemicals  
11 are to be added or injected into the seawater that  
12 enters the pipeline 12. The flow rate of seawater  
13 into the pipeline 12 is generally not constant if  
14 the laying process is continually stopped and  
15 started, and thus it can be difficult to provide the  
16 correct dosage of injected chemicals into the water.

17  
18 The variable choke 20 is generally used to keep the  
19 water level at a near constant in the rising portion  
20 12r of the pipeline 12 (see Fig. 1). The variable  
21 choke 20 is used to ensure that there is at least a  
22 minimum flow of seawater into the pipeline 12 even  
23 where the laying process is stopped and started.  
24 This allows the chemical additives to be injected  
25 into the seawater at the correct dosage more easily  
26 by maintaining a substantially constant flow of  
27 water into the pipeline 12.

28  
29 The isolating valve 22 is used to control the  
30 flooding of the pipeline 12 and in particular is  
31 used to initiate the process of flooding the  
32 pipeline 12. The isolating valve 22 is typically

1 opened at the surface before the apparatus 10 and  
2 the end 12a of the pipeline 12 are lowered to the  
3 seabed 4. Thus, flooding of the pipeline 12 is  
4 initiated as it is being laid, thereby increasing  
5 the weight of the pipeline 12 as it is being laid.  
6 The increase in weight during laying of the pipeline  
7 12 due to the intake of water has the potential to  
8 allow the wall thickness of the pipeline 12 to be  
9 reduced. This is because the weight of the pipeline  
10 12 is being increased by the flooding action of  
11 apparatus 10, and thus the pipeline 12 is relatively  
12 heavy as it is laid on the seabed 4, or at least  
13 shortly after.

14  
15 Thus, there is no requirement to increase the wall  
16 thickness of the pipeline 12 purely for stability  
17 during and after the laying operation. The pipeline  
18 12 can thus comprise conventional pipe with a  
19 standard wall thickness that does not have to be  
20 increased purely for stability purposes. Thus, a  
21 pipeline with a reduced wall thickness (a reduction  
22 of around 3mm or more being typical) when compared  
23 with pipeline used in conventional methods, over the  
24 entire length of the pipeline 12 (typically many  
25 kilometres and possibly hundreds of kilometres in  
26 length) has the potential for significant cost  
27 savings. It will be appreciated that a pipeline  
28 with an increased wall thickness is more expensive  
29 than standard pipeline due to the additional  
30 material that is required to add weight purely for  
31 stability purposes. Furthermore, the equipment on  
32 the lay barge 2 does not have to handle the heavier



1 pipeline that has increased wall thickness, thus  
2 also providing cost savings.

3  
4 There can also be savings in terms of time as the  
5 pipeline 12 with the reduced wall thickness is  
6 easier to handle and can thus be laid more quickly.  
7 This also has the potential to reduce costs as the  
8 lay barge 2 is required for a lesser amount of time.

9  
10 Furthermore, the pipeline 12 is more lightweight and  
11 smaller than the pipeline with the increased wall  
12 thickness and thus more of the pipeline 12 can be  
13 stored on the lay barge 2 and in a more compact  
14 area. This also has the potential to save costs as  
15 the additional amount of pipeline 12 that can be  
16 stored on-board the barge 2 results in the stock  
17 having to be replenished less often by a service  
18 vessel or the like, thereby saving on associated  
19 costs.

20  
21 The apparatus 10 optionally includes an injection  
22 pump 28 that is capable of injecting or pumping  
23 additive chemicals into the conduit 16 and thus the  
24 pipeline 12. The additive chemicals are typically  
25 stored in a reservoir 30, although it will be  
26 appreciated that a number of reservoirs 30 and/or  
27 pumps 28 may be used, depending on the particular  
28 chemicals that are to be added to the seawater. The  
29 injection pump 28 is driven from a high-pressure  
30 supply 32 through an injection control valve 34.  
31 The injection control valve 34 can control the flow  
32 of the injected chemicals according to the

1 prevailing hydrostatic pressure, or at a flow rate  
2 that varies with the water flow rate into the  
3 pipeline 12 (e.g. to be approximately proportional  
4 to the amount of water flowing into the pipeline  
5 12). The latter can be derived from a pressure  
6 differential across the orifice plate 18 via  
7 differential pressure lines 36, 38. Alternatively,  
8 the injection pump 28 can be driven from a system of  
9 fixed or variable orifices that can control the rate  
10 of adding of the chemicals.

11  
12 The differential pressure between the interior of  
13 the pipeline 12 and the surrounding seawater can  
14 also be used for chemical injection of additives.  
15 For example, a venturi, orifice or a fixed choke may  
16 be used where the venturi etc is coupled to a bag or  
17 the like of chemical additives at the orifice of the  
18 venturi. The bag or the like is typically at least  
19 partially flexible so that the pressure of the  
20 surrounding seawater can act on it. The pressure on  
21 one side of the venturi is typically at the same  
22 pressure as the surrounding seawater, and the  
23 pressure acting on the bag of additives is also at  
24 the same pressure as the surrounding seawater. The  
25 orifice in the venturi is at a lower pressure and  
26 thus the chemicals are sucked in from the bag  
27 because of the pressure differential. The pressure  
28 at the orifice will vary as the flow rate of water  
29 therethrough varies, and thus the chemicals are  
30 added in approximate proportion to the flow rate.  
31

1     Thus, apparatus 10 facilitates chemical treatment of  
2     the seawater before it enters the pipeline 12 as it  
3     is being laid. This can be used for numerous  
4     purposes, such as for de-scaling, prevention of  
5     green growth, anti-corrosion and can also facilitate  
6     leak detection during pressure testing, as will be  
7     described. Thus, the chemical injection of selected  
8     additives provides numerous benefits over simply  
9     allowing untreated seawater to flood the pipeline  
10    12.

11  
12    Towards the completion of the pipe laying process,  
13    the hydrostatic pressure difference diminishes as  
14    the pipeline 12 floods, and the pressure difference  
15    between the interior of the pipeline 12 and the  
16    surrounding seawater will eventually decay to zero.  
17    This is dependent upon whether the distal end of the  
18    pipeline 12 remains on the lay barge 2 or is lowered  
19    to the seabed 4. If the distal end remains on the  
20    lay barge 2, flooding of the pipeline 12 may slow  
21    down or cease, but this may not be the case until  
22    substantially all of the pipeline 12 is laid on the  
23    seabed 4. It is therefore useful to provide a means  
24    by which pressurised water can be admitted to the  
25    pipeline 12 to completely flood it after the  
26    hydrostatic head has diminished. Where the distal  
27    end is lowered to the seabed (e.g. to be retrieved  
28    later for further extension to the pipeline 12), the  
29    distal end can be fitted with an air release valve.  
30    As the end is lowered to the seabed 4, the flooding  
31    of the pipeline 12 continues under the hydrostatic  
32    head of water above it and the air that remains in

1 the distal end is vented through the air release  
2 valve.

3  
4 In the embodiment shown in Fig. 2, a boost pump 40  
5 is provided that is operable via a remotely operated  
6 valve 42. The valve 42 is typically controlled via  
7 a control line 43 from the surface, or may be  
8 operated by a diver, ROV or an autonomous vehicle  
9 (AUV). Alternatively, the valve 42 may be operated  
10 in response to a drop in the flow rate of water into  
11 the pipeline 12. The boost pump 40 can be powered  
12 from the surface or preferably from a local power  
13 supply such as from the ROV or some other power  
14 supply (e.g. batteries, hydraulic power source etc).  
15 The boost pump 40 is preferably located downstream  
16 of the injection pump 28 so that chemicals may be  
17 added to the water used to flood the pipeline 12.

18  
19 Conduit 16 optionally includes a one-way or check  
20 valve 45 to prevent the flow of water back towards  
21 the intake filter 14.

22  
23 The apparatus 10 optionally includes a pig (not  
24 shown) that is propelled along the pipeline 12 as it  
25 is being laid and flooded. The position of the pig  
26 within the pipeline 12 can be used as an indication  
27 of the amount of flooding, and thus it is desirable  
28 to track the location of the pig within the pipeline  
29 12 and this can be done using any conventional means  
30 (e.g. a telemetry system). Use of a pig in certain  
31 embodiments provides the advantage that the flow  
32 rate of water into the pipeline 12 can be

1 controlled. Further, as the movement and location  
2 of the pig in the pipeline 12 can be monitored, the  
3 extent of flooding of the pipeline 12 can also be  
4 monitored.

5  
6 Additionally, it is advantageous to monitor the flow  
7 rate of the water into the pipeline 12 as it is  
8 being flooded. Thus, the apparatus 10 may include a  
9 flow recording device (not shown) such as a dial  
10 that can be read by an underwater camera provided on  
11 an ROV or AUV. The flow recording device can be of  
12 any conventional type, and can be electrically or  
13 otherwise coupled (e.g. via a telemetry system) to  
14 the surface for remote monitoring of the water flow  
15 rate.

16  
17 Thus, apparatus 10 facilitates flooding of the  
18 pipeline 12 as it is being laid. This facilitates a  
19 reduction in the wall thickness of the pipeline 12  
20 thereby having the potential to save money and time.  
21 Furthermore, the laying and flooding of the pipeline  
22 12 can be achieved in one operation, thus providing  
23 further savings in terms of costs and time. This is  
24 particularly the case where the pipeline 12 would be  
25 laid using a lay barge 2 and then flooded using a  
26 large-bore, high-pressure conduit dropped from a  
27 support vessel (not shown). However, flooding of  
28 the pipeline 12 as it is being laid has the  
29 advantage that only the lay barge 2 or vessel is  
30 required, and this can significantly reduce costs by  
31 avoiding the use of an additional surface or support

1 vessel that is normally required to flood the  
2 pipeline 12 (and optionally pressure test it).

3  
4 The cost of the operation can be reduced further by  
5 using the apparatus 10 described above to pressure  
6 test the pipeline 12 once it has been laid and  
7 flooded to ensure that there are no fluid leaks, as  
8 this is generally desirable.

9  
10 To provide for the pressure testing of the pipeline  
11 12, apparatus 10 includes a low-flow rate but high-  
12 pressure pump 50 so that the pressure testing (also  
13 called hydro testing) can follow the laying and  
14 flooding of the pipeline 12 without the intervention  
15 of a support or surface vessel, or at least to a  
16 lesser extent than is conventional in the art.

17  
18 Pump 50 is coupled into a conduit 52, the inlet of  
19 which is preferably coupled downstream of the  
20 injection pump 28 so that chemicals can be added to  
21 the water if required. The operation of pump 50 is  
22 controlled by a remotely operated valve 54 that can  
23 be operated via a control line 56 from the surface,  
24 or can be actuated by a diver, ROV or AUV.

25 Alternatively, the valve 54 may be operated  
26 automatically when the flooding of the pipeline 12  
27 is complete. An isolating valve 58 is located in  
28 the conduit 52 upstream of the pipeline 12 so that  
29 the conduit 52 can be opened and closed as required.

30

31 The pump 50 is actuated to provide a high-pressure  
32 flow of water, typically at a relatively low flow

1 rate, into the pipeline 12. The high-pressure, low-  
2 flow of water increases the pressure within the  
3 pipeline 12 so that any leaks or weak points in the  
4 pipeline 12 can be detected. Chemicals may be added  
5 to the seawater to facilitate identifying the source  
6 of any leaks.

7  
8 Only a relatively low flow rate of water is required  
9 as the pipeline 12 is already filled with seawater  
10 and only the internal pressure within the pipeline  
11 12 need be increased. The volume of water that  
12 enters the pipeline 12 is considerably less than  
13 that required to flood it.

14  
15 Referring now to Fig. 4 there is shown as an example  
16 a 12-inch (approximately 300 millimetre) bore  
17 pipeline 200 that is 5 kilometres long and has been  
18 laid on the seabed 202 between two installations  
19 204, 206 in a deep-water field. Apparatus 10 is  
20 coupled to the pipeline 200 using a conduit 208 that  
21 is coupled to a pipeline inlet port, for example.  
22 Apparatus 10 is typically used to flood the pipeline  
23 200 and can then be used to pressure test it in  
24 consecutive operations.

25  
26 The flooding of the pipeline 200 typically requires  
27 a volume of water to fill the pipeline 200 (e.g.  
28 using the above described apparatus 10) that is in  
29 the order of 360 cubic metres. The additional  
30 volume of water required to raise the internal  
31 pressure of the pipeline 200 to around 700 bar  
32 (10150 psi) is 14½ cubic metres. This is only a

1 small percentage (in the order of 4%) of the volume  
2 of water required to fill the pipeline 200 in the  
3 first instance, and highlights the difference in  
4 required capacity between a relatively low-pressure,  
5 high flow-rate flooding pump (e.g. boost pump 40)  
6 and a high-pressure, low-flow pressure testing pump  
7 (e.g. pump 50).

8  
9 The pump 50 used for the pressure test typically  
10 requires to pressurise the pipeline 200 at  
11 approximately 1 bar per minute, and thus the  
12 required flow rate from pump 50 would be in the  
13 order of 21 litres per minute. If the pipeline 12  
14 is to be pressured at around 3 bars per minute, then  
15 the corresponding flow rate is around 62 litres per  
16 minute.

17  
18 Thus, the power required to provide these flow rates  
19 at the required pressures would reach a maximum as  
20 the final pressure is approached, and this maximum  
21 would be around 23 kilowatts (31 horse power) for  
22 the 1 bar per minute flow rate, and 60 kilowatts (94  
23 horse power) for the 62 litres per minute flow rate.

24  
25 Thus, the total energy required to pressurise the  
26 pipeline 200 during the pressure test is typically  
27 around 500 MJ. This energy can be provided by  
28 dropping an electrical cable from a supply vessel  
29 and coupling this to the pump 50. However, this has  
30 a drawback in that the surface vessel would require  
31 to remain *in situ* until the pressure test is  
32 complete, and this may take several hours as the



1 pressure needs to be increased to the predetermined  
2 testing pressure, and then held at that pressure for  
3 a period of time, typically in the order of 24  
4 hours.

5  
6 It is therefore preferred that the energy required  
7 to drive the pump 50 is provided locally (i.e.  
8 subsea) as this has the advantage that the surface  
9 vessel is not required to remain *in situ* during the  
10 pressure test, providing significant costs  
11 advantages.

12  
13 For example, the energy can be provided by a local  
14 (subsea) power supply such as a bank of suitable  
15 batteries. The batteries can be charged during  
16 flooding of the pipeline 200 by coupling an  
17 alternator or the like into the conduit 16 at an  
18 appropriate place so that the flow rate through the  
19 conduit 16 drives a turbine in the alternator that  
20 generates a sufficient current to charge the  
21 batteries.

22 It is preferred that the power to the pump 50 is  
23 provided locally so that there is no surface  
24 connection, although this may be possible in  
25 relatively shallow water or where there is access to  
26 a surface vessel. There is also the potential to  
27 use a smaller boat with less personnel as the pump  
28 used for pressure testing would not be required on  
29 board the vessel; all that is required is an  
30 electrical cable to be dropped to the seabed 202 for  
31 coupling to the apparatus 10 (e.g. by ROV 210).

1  
2 As an alternative to using power from batteries or  
3 from an electrical cable from a surface vessel, the  
4 power for the pump 50 may also be provided by the  
5 ROV 210 or an autonomous vehicle (AUV - not shown).  
6 This would require the pump 50 to be provided with a  
7 suitable connector that can be engaged and  
8 disengaged by the ROV 210 or AUV so that power can  
9 be provided. Alternatively, an electrical cable 212  
10 can be coupled between the pump 50 and the ROV 210  
11 (see Fig. 4). Thus, the ROV 210 or AUV would be  
12 coupled to the pump 50 in any conventional manner to  
13 provide power thereto, and then de-coupled once the  
14 pressure test is complete.

15  
16 Alternatively, the pump 50 may be pneumatically or  
17 hydraulically powered, the latter possibly being  
18 provided by the ROV 210 as this can provide  
19 hydraulic power.

20  
21 It will be appreciated that the above apparatus 10  
22 has been described where the pump 50 forms a part of  
23 the apparatus 10, but it will also be appreciated  
24 that the pump 50 may be provided on a separate  
25 subsea skid from the remainder of the apparatus 10,  
26 100. Having the pump 50 included in a single subsea  
27 skid with the remainder of the apparatus 10 provides  
28 the advantage that only a single piece of equipment  
29 need be lowered to and retrieved from the seabed.  
30 Additionally, the apparatus 10 need only be coupled  
31 to the pipeline once in order to flood it and  
32 pressure test it. There is no requirement to couple

1 and de-couple other equipment to the pipeline using  
2 an ROV for example. Both of these are significant  
3 advantages when the time taken to raise and lower  
4 the apparatus 10 is considered, and also the time  
5 taken to couple and de-couple conventional large-  
6 bore conduits.

7  
8 Indeed, the pump 50 can be used independently of the  
9 remainder of the apparatus 10 that is generally used  
10 to flood the pipeline 12. The pump 50 can be  
11 provided on a separate subsea skid and coupled to  
12 and de-coupled from the pipeline 12 using a diver,  
13 ROV or AUV as necessary. Thus, the pump 50 does not  
14 have to be used with the remainder of the apparatus  
15 10 described above, and could be used with other  
16 conventional methods of flooding the pipeline 12.  
17 However, it will be noted that combining the pump 50  
18 with the remainder of the apparatus 10 has  
19 significant advantages in that the flooding and  
20 pressure testing of the pipeline 12 can be done in  
21 consecutive operations, without the intervention of  
22 a vessel, and without having to de-couple and couple  
23 other equipment and apparatus.

24  
25 Referring now to Fig. 3, there is shown an  
26 alternative embodiment of apparatus 100 for flooding  
27 and pressure testing a pipeline 112. Apparatus 100  
28 is shown in Fig. 3 as attached to the end 112a of  
29 the pipeline 112 and is similar to apparatus 10, so  
30 like numerals prefixed "1" have been used to  
31 designate like parts.

32

1 In the embodiment shown in Fig. 3, the pump 50 has  
2 been replaced by a gas accumulator bottle or a bank  
3 of such, generally designated 160, that is capable  
4 of providing high-pressure, low-flow gas into a  
5 reservoir 162 or other container of seawater. As  
6 the flow of gas from the accumulator bottles 160  
7 (typically via a manifold (not shown) so that the  
8 gas flow rate can be controlled) enters the  
9 reservoir 162, the water therein is forced into the  
10 pipeline 112, preferably at high pressure and a low  
11 flow rate. The water already in the pipeline 112 is  
12 compressed, thus increasing the internal pressure to  
13 perform the pressure tests. This particular  
14 embodiment is advantageous as an electrical power  
15 supply is not required.

16  
17 The gas bottles 160 can be filled with gas (e.g. air  
18 or the like) at the surface before the apparatus 100  
19 is lowered to the seabed. A conduit 164 is coupled  
20 to the pipeline 112 so that the pressurised gas from  
21 the bottles 160 can enter the reservoir 162 and  
22 force pressurised water out of it and into the  
23 pipeline 112. A remotely-operated isolating valve  
24 166 is coupled into the conduit 162 so that the flow  
25 of water into the pipeline 112 can be controlled  
26 from the surface (e.g. using a control line 166), or  
27 otherwise controlled (e.g. automatically in response  
28 to the pressure within the pipeline 112).

29  
30 The gas bottles 160 may include a regulating device  
31 (not shown) to control the rate at which gas enters  
32 the reservoir 162 and also to control the pressure

1 of the water from the reservoir 162 as it enters the  
2 pipeline 112. The regulating device can be of any  
3 conventional type, and could be a further remotely  
4 operated valve that can be controlled from the  
5 surface or by a diver, ROV or AUV, or automatically.

6  
7 Embodiments of the present invention provide  
8 numerous advantages over conventional methods for  
9 the laying and flooding of pipelines. In  
10 particular, there is the potential to reduce costs  
11 and time, in addition to using lighter and easier to  
12 handle pipe. Also, there is no requirement to use a  
13 support vessel at the surface to flood and/or  
14 pressure test the pipeline, thus saving significant  
15 costs in terms of manpower and the operation of the  
16 vessel. Furthermore, the present invention can be  
17 used to flood the pipeline as it is being laid, and  
18 then to pressure test it in consecutive operations;  
19 there is no requirement to couple and de-couple  
20 various pumps and other apparatus and equipment to  
21 the pipeline in order to lay it, flood it and then  
22 pressure test it.

23  
24 Modifications and improvements may be made to the  
25 foregoing without departing from the scope of the  
26 present invention.

27  
28  
29

1     CLAIMS

2

3     1.   A method of flooding a pipe as it is being laid  
4     in water, the method comprising the steps of  
5     providing an inlet to the pipe, the inlet having an  
6     opening to admit water, and allowing water to enter  
7     the pipe through the inlet as the pipe is being  
8     laid.

9

10    2.   A method according to claim 1, wherein the  
11    method includes the additional steps of coupling a  
12    pipe inlet port to the pipe, and coupling the inlet  
13    to the pipe inlet port.

14

15    3.   A method according to claim 2, wherein the  
16    method includes the additional step of coupling the  
17    inlet to the pipe before the pipe enters the water.

18

19    4.   A method according to claim 2, wherein the  
20    method includes the additional step of coupling the  
21    inlet to the pipe underwater.

22

23    5.   A method according to any preceding claim,  
24    wherein the method includes the additional step of  
25    actuating flooding of the pipe.

26

27    6.   A method according to claim 5, wherein the step  
28    of actuating flooding of the pipe involves opening  
29    an isolating valve.

30

1 7. A method according to any preceding claim,  
2 wherein the method includes the additional step of  
3 filtering the water that enters the pipe.  
4

5 8. A method according to any preceding claim,  
6 wherein the method includes the additional step of  
7 providing an intake filter at the inlet.  
8

9 9. A method according to any preceding claim,  
10 wherein the pipe is flooded from the end that is in  
11 the water.  
12

13 10. A method according to any preceding claim,  
14 wherein a hydrostatic head of water above the pipe  
15 is used to flood the pipe.  
16

17 11. A method according to any preceding claim,  
18 wherein an end of the pipe provides a vent to the  
19 atmosphere for the air or gas in the pipe during  
20 flooding.  
21

22 12. A method according to any preceding claim,  
23 wherein the method includes the additional step of  
24 adding chemicals to the water that enters the pipe.  
25

26 13. A method according to any preceding claim,  
27 wherein the method includes the additional step of  
28 pumping fluid into the pipe to complete flooding of  
29 the pipe.  
30

- 1     14. A method according to claim 13, wherein the  
2     step[ of pumping fluid into the pipe comprises  
3     actuating a pump to complete flooding of the pipe.  
4
- 5     15. A method according to any preceding claim,  
6     wherein the method optionally the additional step of  
7     pressure testing the pipe after it has been flooded.  
8
- 9     16. A method according to claim 15, wherein the  
10    step of pressure testing the pipe involves the  
11    actuation of a subsea pump.  
12
- 13    17. A method of laying a pipeline in a body of  
14    water, the method comprising allowing the water to  
15    flood the pipeline as it is being laid.  
16
- 17    18. A method according to claim 17, wherein the  
18    method includes the steps of providing an inlet to  
19    the pipeline, the inlet having an opening to admit  
20    water, and allowing water to enter the pipeline  
21    through the inlet as the pipeline is being laid.  
22
- 23    19. A method according to claim 18, wherein the  
24    method includes the additional steps of coupling a  
25    pipe inlet port to the pipe, and coupling the inlet  
26    to the pipe inlet port.  
27
- 28    20. A method according to claim 19, wherein the  
29    method includes the additional step of coupling the  
30    inlet to the pipe before the pipe enters the water.  
31



1 21. A method according to claim 19, wherein the  
2 method includes the additional step of coupling the  
3 inlet to the pipe underwater.

4

5 22. A method according to any one of claims 17 to  
6 21, wherein the method includes the additional step  
7 of actuating flooding of the pipe.

8

9 23. A method according to claim 22, wherein the  
10 step of actuating flooding of the pipe involves  
11 opening an isolating valve.

12

13 24. A method according to any one of claims 17 to  
14 23, wherein the method includes the additional step  
15 of filtering the water that enters the pipe.

16

17 25. A method according to any one of claims 17 to  
18 24, wherein the method includes the additional step  
19 of providing an intake filter at the inlet.

20

21 26. A method according to any one of claims 17 to  
22 25, wherein the pipe is flooded from the end that is  
23 in the water.

24

25 27. A method according to any one of claims 17 to  
26 26, wherein a hydrostatic head of water above the  
27 pipe is used to flood the pipe.

28

29 28. A method according to any one of claims 17 to  
30 27, wherein an end of the pipe provides a vent to  
31 the atmosphere for the air or gas in the pipe during  
32 flooding.

1

2 29. A method according to any one of claims 17 to  
3 28, wherein the method includes the additional step  
4 of adding chemicals to the water that enters the  
5 pipe.

6

7 30. A method according to any one of claims 17 to  
8 29, wherein the method includes the additional step  
9 of pumping fluid into the pipe to complete flooding  
10 of the pipe.

11

12 31. A method according to claim 30, wherein the  
13 step of pumping fluid into the pipe comprises  
14 actuating a pump to complete flooding of the pipe.

15

16 32. A method according to any one of claims 17 to  
17 31, wherein the method optionally the additional  
18 step of pressure testing the pipe after it has been  
19 flooded.

20

21 33. A method according to claim 32, wherein the  
22 step of pressure testing the pipe involves the  
23 actuation of a subsea pump.

24